STUDY OF DUST NEBULA AROUND THE WHITE DWARF 0352-049 IN INFRARED ASTRONOMICAL SATELLITE MAP

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Abstract

In this work I have studied the far infrared spectra of the dust structure around the White Dwarf 0352-049 available in Sky view virtual observatory (http://skyview.gsfc.nasa.gov) in Infrared Astronomical Satellite map. There is Gaussian like distribution of relative flux density in both 100 micron and 60 micron FITS image. The temperature of the whole dust structure lies between maximum 24.09 K to minimum 21.87 K with fluctuation of 2.22K and average value 23.09 K. The distribution of temperature is also Gaussian in nature. The small fluctuation and Gaussian distribution of temperature suggests the dust structure is evolving independently and the less disturbance from external sources. The total dust mass of the structure is found to be 0.07 times Solar mass and that of gas is 13.66 times Solar mass. The Jeans mass of the structure is 5.25 times Solar mass, less than the total mass of gas in the structure, suggesting the possibility of formation of star by gravitational collapse in future. The size of structure is 24.48 parsec × 8.10 parsec. Also the study of inclination angle suggests that the three-dimensional shape of structure is uniform and regularly shaped.

Keywords: - Infrared, Dust Nebula, IRAS

1. Introduction

The infrared astronomy is the branch of astronomy that studies the infrared source in the galaxy with the help of infrared light. The ubiquitous source of infrared light in galaxy is the dust which blends almost uniformly within the interstellar medium (ISM). The dusts absorbs the ultraviolet radiation emitted from nearby sources and reradiates in infrared band. Dust are also important because they controls the chemistry of ISM. Also, the possibility earth like planetary system is possible due to the presence of dust in ISM.

Interstellar dusts form during post main sequence evolution phase of star. The most of the ejected mass from stars due to stellar wind remain as a dust in ISM. However, this mechanism contributes very less fraction of interstellar dusts. The majority of dust forms by accretion and coagulation of grains in the cold region of ISM and many process are still unknown.

In the late phase of intermediate mass star, the compressed core remains as a white dwarf with envelope of dust surrounding it, called planetary nebula. The study of dust around white dwarf can reveal important archeological information about the white dwarf and parent star from which it is formed.

Infrared Astronomical Satellite (IRAS) is the first ever space based telescope which studies the infrared astronomical sources. It has many groundbreaking discoveries and many sources are still waiting for identification.

In this work, I have studied the dust structure around the White Dwarf 0352-049 in IRAS map, located at galactic longitude; 194.89 and galactic latitude; -40.20, in 60 μm and 100 μm IRAS images. The relative flux , dust color temperature and dust mass within the dust structure is presented in this work.

2. Methodology

2.1. Dust Color Temperature

The dust color temperature is estimated by using the formula given by Schnee et al. (2005), given as;

$$T_d = \frac{-96}{\ln[R \times 0.6^{(3+\beta)}]} \ldots\ldots\ldots\ldots\ldots \text{(2.1)}$$

here R is the ratio of relative flux densities in 60 μm and 100 μm FITS (Flexible image transport system) image. The value of spectral emissivity β is used 2 assuming the dust grain in the crystalline state (Dupac et al, 2003).

2.2. Estimation of Dust Mass

Mass of dust in each pixels of FITS image are estimated using the formula given by Hildebrand et al. (1983).

$$M_{dust} = 0.4 \left[\frac{S_\nu D^2}{B(\nu,T)} \right] \ldots\ldots (2.2)$$

here, S_ν = absolute flux = F(100 μm) × MJy/Str × 5.288 × 10^{-9} and 1 MJy/Str = 1 × 10^{-20} kg s^{-2} in SI unit, D = distance, $B(\nu,T)$ = Planck's function of blackbody radiation.

2.3. Inclination Angle

The inclination angle is the angle between the line of slight and the normal vector of the plane of the nebular. This is estimated by using the Holmberg (1946) formula given by,

$$\cos^2 i = \frac{\left(\frac{b}{a}\right)^2 - (q^*)^2}{1-(q^*)^2} \ldots\ldots (2.3)$$

here, $\frac{b}{a}$ is the ratio of minor and major diameter of the nebular and q^* is the intrinsic flatness.

3. Result and Discussion

3.1. Contour Map

The FITS image at 60 μm and 100 μm taken from Sky view virtual observatory (source: web[1]) is processed in ALADIN 9.0 software. We draw two contours with level 47 and 20, all 792 pixels inside outer contour 47 are included for study. The relative infrared flux at 60 and 100 μm are extracted using ALADIN 9.0.

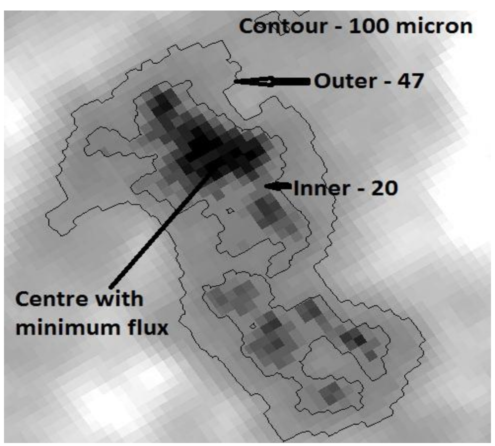

Figure:3.1 Contour levels drawn in 100 μm FITS image using ALADIN 9.0.

3.2: Contour Plot: Relative Flux Density

The variation of relative infrared flux is studied using contour plot. Separate plots are drawn for 60 μm and 100 μm image. A linear relationship between these two flux can give the average temperature of the structure. The similarities observed in the relative flux at 60 and 100 μm might be due to the blackbody emission from large dust presence within the structure.

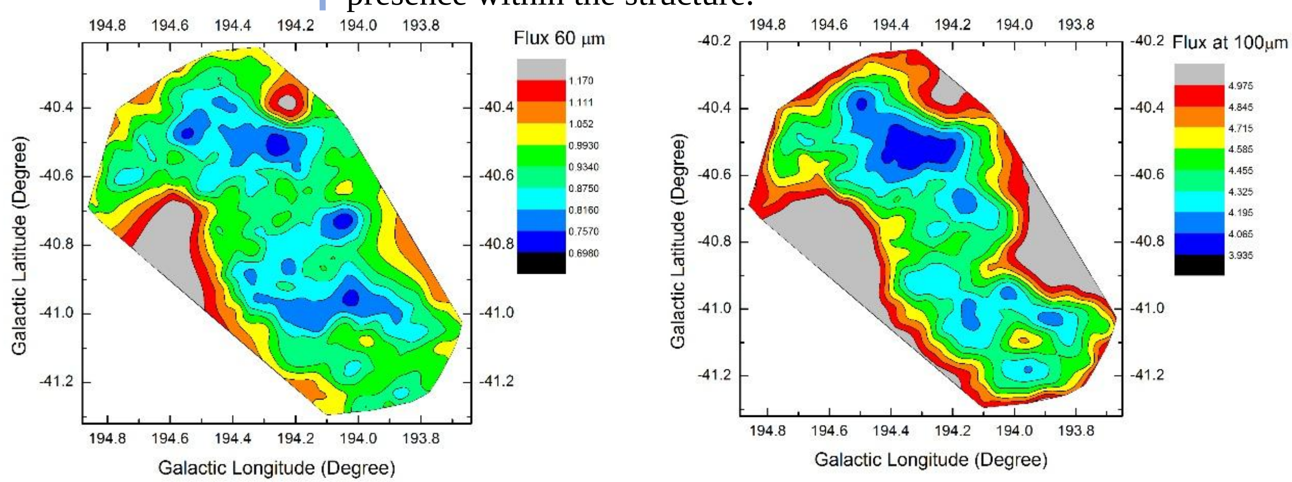

Figure:3.2 Contour plot of relative flux at 60 μm (left) and 100 μm (left)

3.2. Dust Color Temperature and Mass Estimation

The dust color temperature and mass of each pixels are calculated by following Schnee et al. (2005) and Hildebrand et al. (1983) respectively. The temperature and mass distribution within the structure is shown in figure below. The maximum and minimum temperature within the structure is found 24.09 K and 21.87 K, with range 2.22.K and average value 23.09K.

The slope linear plot between for 60 μm and 100 μm flux can also gives the average temperature of the structure, which is 23.69 K. The average value of temperature from both method are nearly equal.

For the calculation of dust mass we use the distance to the structure 1219pc using SIMBAD (source; web[2]). The total dust mass of all pixels with the structure is 1.36×10^{29} kg ($0.07 M_{\odot}$) and mass of gas is 2.72×10^{31} kg ($13.66 M_{\odot}$).

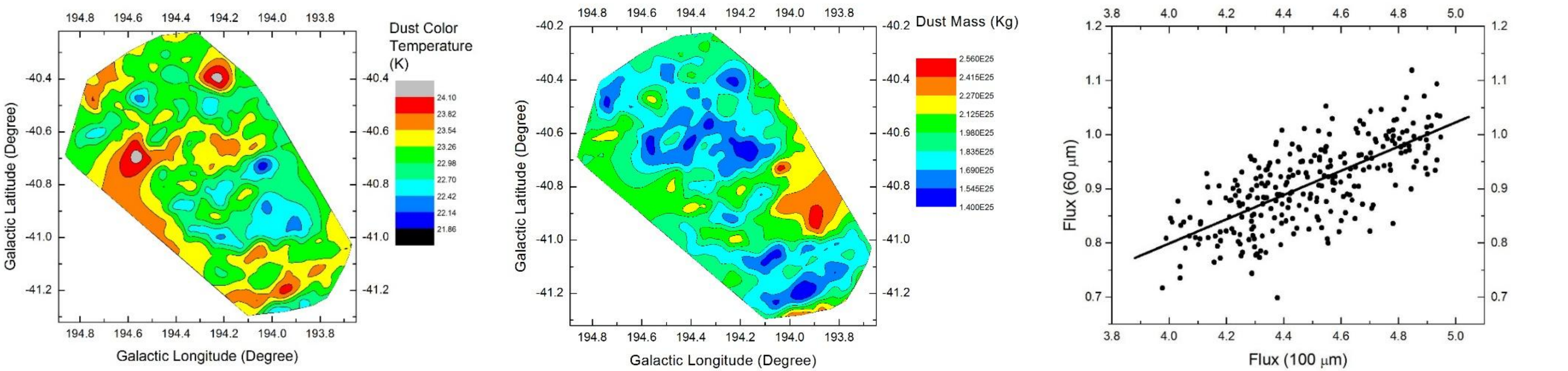

Figure:3.2 Contour plot of dust color temperature (left) and dust mass (middle) in every pixels within the structure, showing the inverse relation between temperature and mass. A linear relation between flux at 60 and 100 μm is shown in right image.

3.4. Gaussian Plot of Flux, Temperature and Mass

There are 792 pixels within the dust structure. The data of flux, temperature and mass of each pixels are binned in appropriate size to study the nature of data. The Gaussian fit for each data is shown in the figure. The graph of flux at 60 μm and temperature show Gaussian nature and flux at 100 μm and mass are slightly deviated from Gaussian nature.

From Gaussian fit of temperature, we can conclude that the temperature distribution is symmetric and effect of external radiation sources in background is very small.

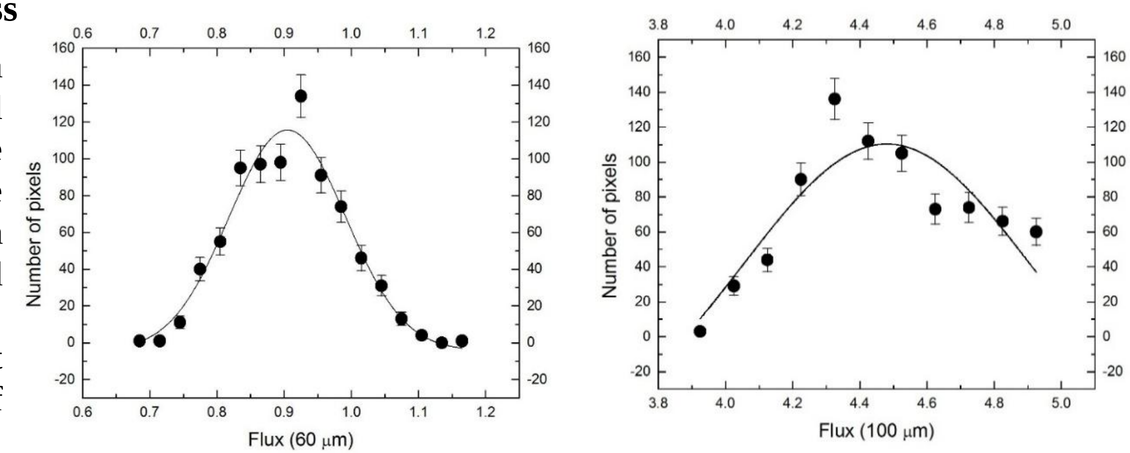

Figure: 3.4, Gaussian fit for 60 μm flux (left), 100 μm (right),

3.4. Size, Inclination Angle and Jeans Mass

The angular dimension of the structure (69.0 arcsec × 22.84 arcsec) is converted into linear dimension by using the formula of circle; $l = d \times \theta$, where, l is the linear and θ is angular size and d is the distance, 1219pc. The size of structure is; 24.48 pc × 8.10 pc.

The inclination angle is calculated using Holmberg (1946) formula. Which varies uniform and regular manner from inside to outside representing the dust structure is uniformly shaped and regularly structured.

The Jeans mass of the structure is 1.04×10^{31} kg ($5.25M_{\odot}$), which is less than the total mass of gas ($13.66M_{\odot}$) within the structure. This suggest the possibility of the star formation activity in future.

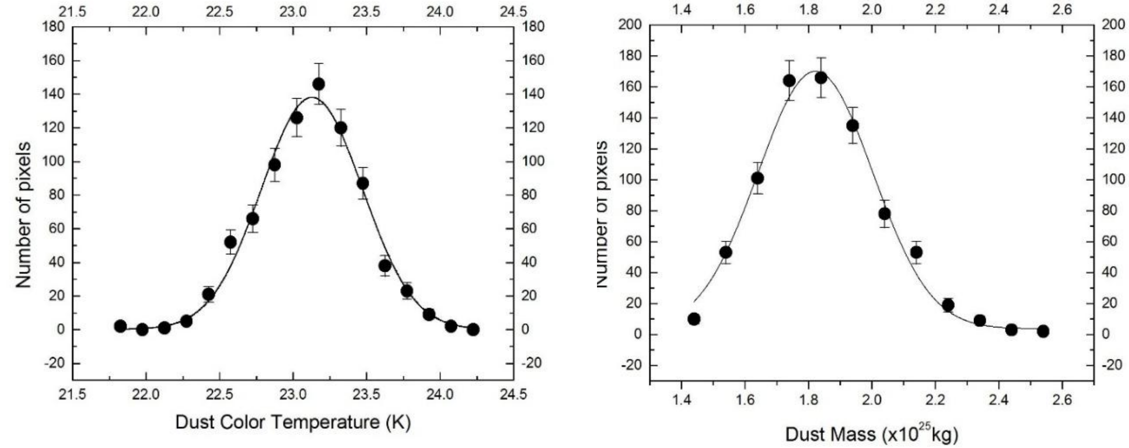

Figure: 3.4, Gaussian dust temperature (left) and dust mass (right).

4. Conclusions

Following are the conclusions of this research work;

1. The study of relative flux density at 60 μm and 100 μm FITS image suggests that the dust structure consists of the large dust grains having similar blackbody features at both 60 μm and 100 μm wavelength.
2. The average temperature of the structure is $\sim 22K$, suggesting that the dust cloud is not Cirrus type cloud.
3. The temperature variation within the whole structure is $\sim 2K$ and the distribution of temperature fits in Gaussian model. The both result suggests that this structure is evolving independently and less effected from the sources in background.
4. The study of Jeans criteria of the structure allowed the possibility of star formation activity within the structure.
5. The study of inclination angle suggests that the structure is uniformly shaped and regularly structured in morphological point of view.

5. References

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- web[2]: http://simbad.u-strasbg.fr/simbad/

5. Acknowledgement

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